

Effect of Field Non-uniformity on Inner Tracking

J. Hylen

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The magnetic field for SDC inner tracking can be made sufficiently uniform that there should be no degradation of momentum resolution compared to that expected for an exactly uniform field. In fact for the magnet geometry explored in this note one might be able to use a uniform field model in the track reconstruction code. The benefits of not having to use a non-uniform field model would include having simpler code, saving considerable CPU time in track reconstruction, and having a cleaner situation for pattern recognition.

Robert Wands has produced a new field map (tu_n114) for the U-type solenoid. This geometry has iron in the SDC calorimetry to make the field more uniform in the inner tracking volume. In this particular version, the iron actually intrudes inside the coil (fig 1). The field lines for this map are plotted in fig. 2. Note that although the field is very uniform in most of the tracking volume, there are large deviations from axial near the edge of the tracking volume at $Z = 4$ meters.

Since the equation for the deviation of a track in a magnetic field is

$$\frac{d\vec{p}}{dt} = q\vec{v} \times \vec{B}$$

one is interested in the cross product of the track direction and the magnetic field. This cross product is plotted in fig. 3 for some values of radius and Z . In this plot, the "track" direction is taken as a straight line from the center of the detector, and the result is normalized to what would be obtained for an exactly uniform axial field. The deviations from a uniform field are large at large Z .

The p_t kick given a track by the field is just the integral of this cross product over the trajectory. Approximating a high momentum track as a straight line from the center of the detector, one obtains the field integrals shown in fig. 4. Here again, the result is normalized to what one would obtain for an exactly uniform field. The deviation from what one would obtain for a uniform field is everywhere less than 5%.

To obtain the position of the track at the outer edge of the detector, one needs to integrate the above equation a second time. That is, for a high momentum track produced at the origin along the z axis, the equation for the track position at the outer edge of the detector r_{max} is approximately

$$y = \frac{q}{p_t} \int_0^{r_{max}} dr \int_0^r d\vec{x} \times \vec{B}$$

This integral is shown in fig. 5 for various pseudo-rapidities. Again, the integration is done along a straight line from the origin and is normalized to that obtained for an exactly uniform field. The resulting deviations are less than 0.2% for most of the rapidity coverage, and are less than 0.6% everywhere. The effect on the calculated momentum will be of the same order as this. In fig. 6, these hit position deviations are compared to the one standard deviation contour expected from multiple scattering. The momentum dependence of both of these drops out (approximately) when plotted as a ratio to the total deflection.

In summary, since the deviations from uniform field in this proposed magnet geometry are near the end of the tracking volume, they have little effect on the hit positions in the tracking chambers. The effect of the non-uniform field is less than the effect of multiple scattering.

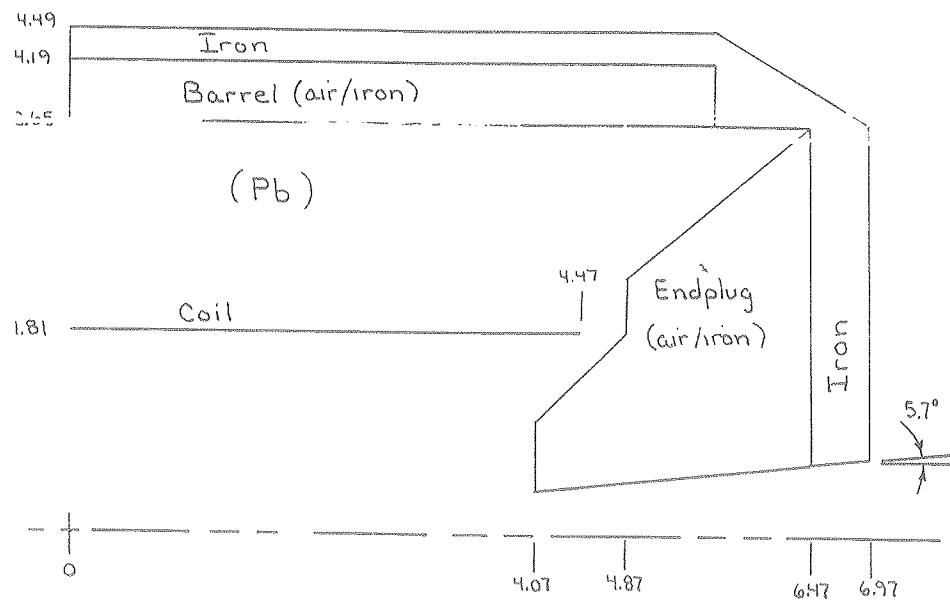


fig. 1

SDC magnetic field lines (tu-n144)

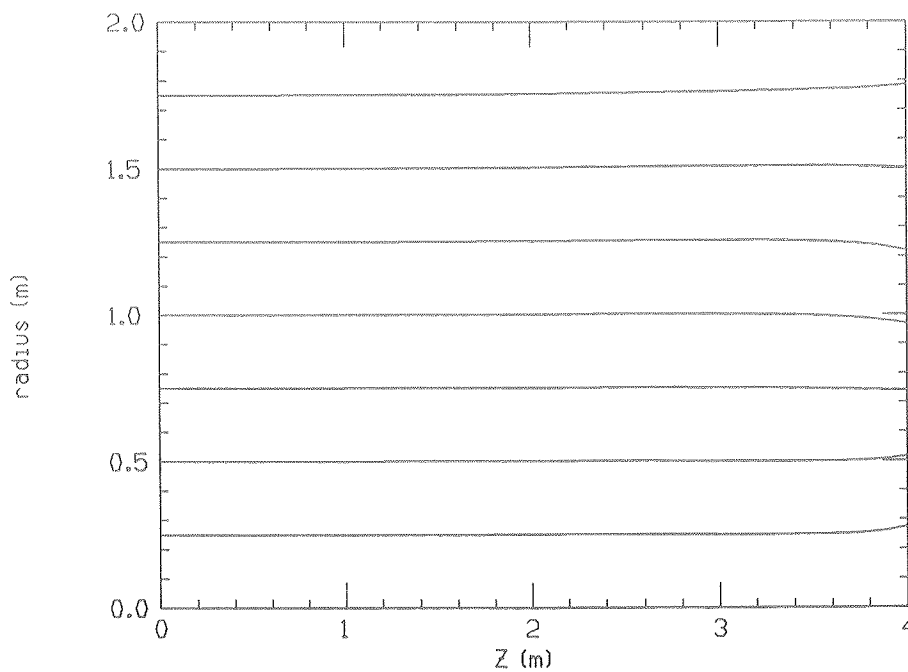


Fig. 2

Field magnitude compared to uniform field

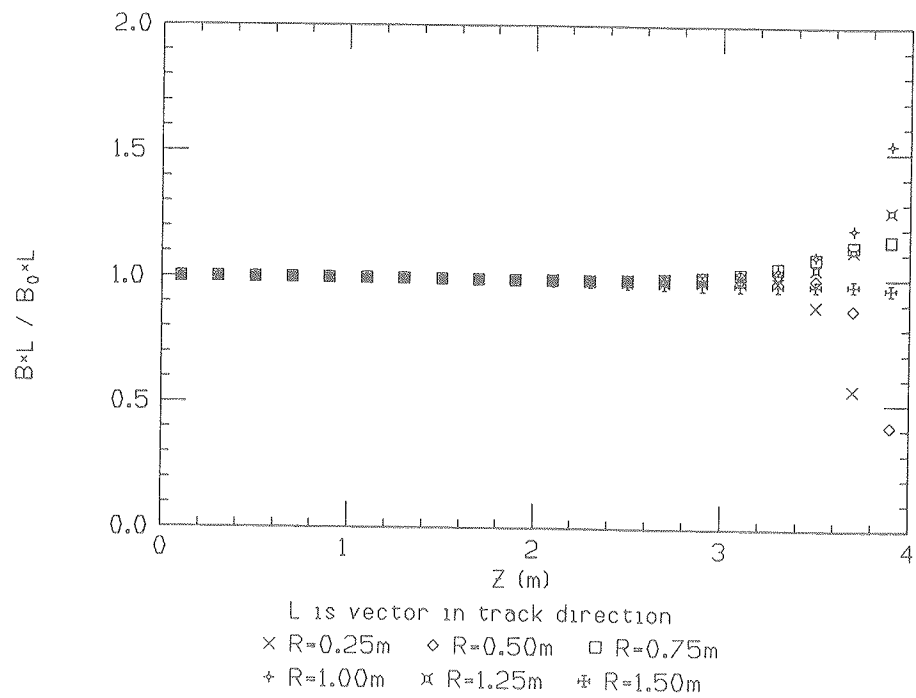


Fig. 3

Field integral along track comp. to uniform field

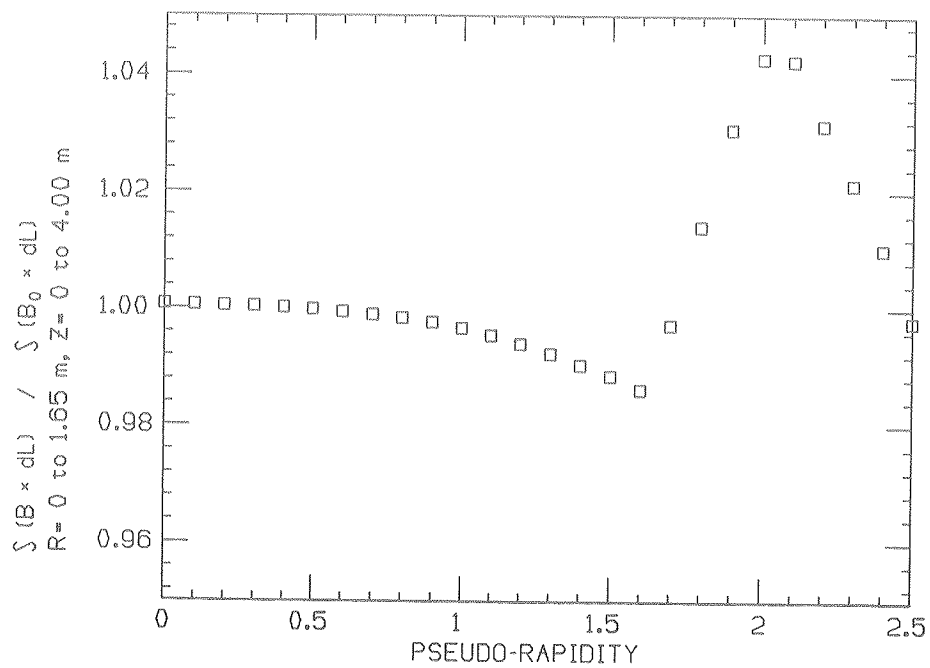


Fig. 4

Double integral of field comp. to uniform field

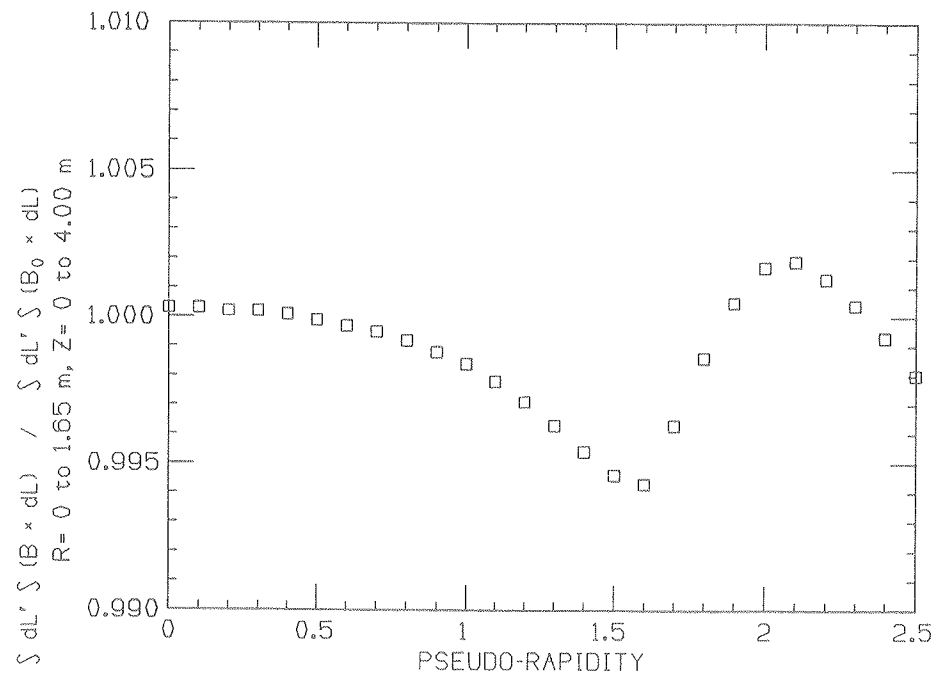
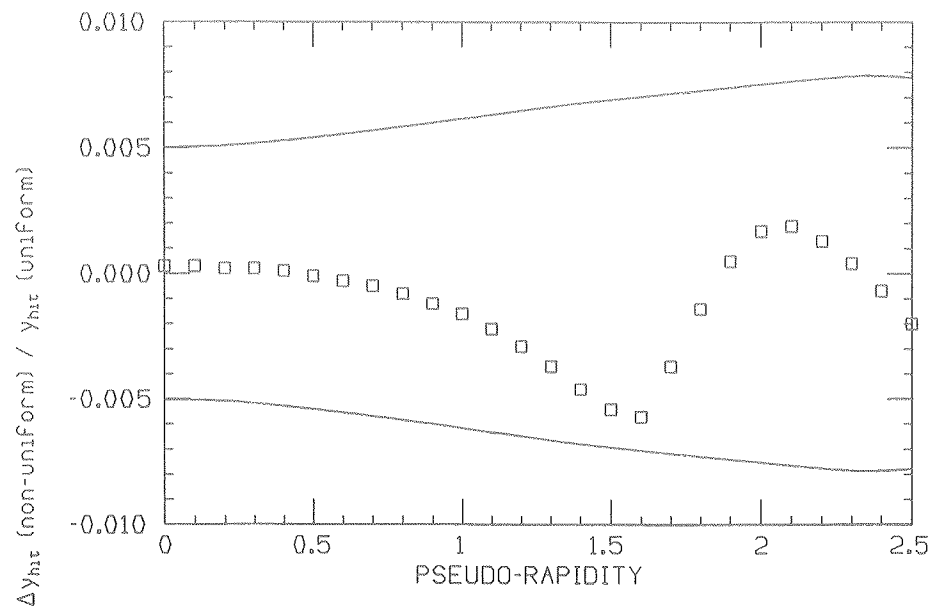


Fig. 5

Fractional track deflection



Deviation of hit position due to field non-uniformity (points),
and multiple scattering (lines), compared to total deflection
by solenoid field

Fig. 6